Report for 2004NE78B: Hydrogeological Controls of Salinity Patterns in the Sand Hills Lakes, NE

- Articles in Refereed Scientific Journals:
  - Tcherepanov, E.N., V.A. Zlotnik, G.M. Henebry, Using Landsat Thermal Imagery and GIS for Identification of Groundwater Discharge into Shallow Groundwater - Dominated Lakes, 2005, Int. J. Remote Sensing, in press.
  - Zlotnik, V.A., M. Burbach, J. Swinehart, D. Bennett, S. Fritz, D. Loope, 2005, A case study of direct push methods for aquifer characterization in dune-lake environments, Ground Water, in revision
- Other Publications:
  - Goss, D., and V.A. Zlotnik, 2004, Studies of permeability in shallow eolian sediments in the Nebraska Sand Hills and Great Sand Dunes National Monument, Colorado, GSA Abstracts with Programs, Denver, Colorado, November 7-10, 2004, Vol. 36, No. 5, p. 125.

Report Follows

Summary

This project is a part of a program of studies of the Sand Hills and Nebraska lakes to forecast their water chemistry under various scenarios of climate change. The long-term goal of our research is to develop a methodology of simulating lake salinity and salinity dynamics. The specific goal of this project is to collect background data for understanding lake-groundwater interactions in the Sand Hills area. This topic is important for sustainability of water resources of the Sand Hills.

Specific Objectives: The objectives of this study include characterization of the chemistry of the aquifer and adjacent lakes across a broad range of salinity (from freshwater to hypersaline) in a restricted area of the Sand Hills. These lakes were located in the vicinity of Crescent Lake National Wildlife Refuge. The specific objectives included 5 tasks: 1) Collection of Salinity Data; Map; 2) Preliminary Characterization of Aquifer; 3) Evaluation of Basic Groundwater Chemistry; 4) Core Collection; 5) Hydraulic Conductivity Evaluation.

Results – Task 1: Collection of data for mapping spatial patterns of lake salinity including water samples and field data on TDS, Secchi depth, temperature, pH, conductivity, total alkalinity, $\delta^{18}O$ and δ^2H in 37 "wet" lakes in the area of approximately 15 km by 15 km. Eleven lake samples have been analyzed for water chemistry (in the Water Sciences Lab for anions and in the Groundwater Chemistry Lab for cations).

Results – Task 2: Aquifer and groundwater have been characterized in eleven locations (low areas in the vicinity of the sampled lakes). These locations were arranged in three transects in a southwest-to-northeast direction. A Geoprobe Systems® direct push system (model DT6610DT) with soil electrical conductivity probe (model SC400) was used at distances from 5 to 100 m from the lake strandlines. In each location, continuous vertical EC profiles were collected to depths up to 15 m. An expected contact of eolian sand with Ogallala, or buried valley, or organic sediments was not found in soil electrical conductivity logs, =which show relatively uniform lithological conditions in the vicinity of the lakes.

Results – Task 3: Evaluation of basic groundwater chemistry indicates that lake water varied in TDS between 318 mg L^{-1} and 121,000 mg L^{-1} with a mean of 2,950 mg L^{-1} and standard deviation 16,735 mg L^{-1}, pH varied between 8.7 and 10.57. TDS for groundwater samples varied from 127 mg l^{-1} at a site 2 to 1727 mg l^{-1} at a site 3, with a mean of 477 mg l^{-1} and a standard deviation of 439 mg l^{-1}. Currently, these data are being analysed and interpreted.

Results - Task 4: Collection of 4-foot cores was performed in eleven locations for better delineation of stratigraphy following EC profiling, slug test, and water chemistry collection. Short cores (12-28 cm) were also collected from 2 lakes of contrasting water chemistry (Reno, Whitehead) to assess the stability of water chemistry based on diatom analysis. Both cores are undated but likely span one to two centuries. The diatom stratigraphy at both sites suggests alterations in surface water salinity and alkalinity over recent time.

Results – Task 5: Hydraulic conductivity (*K*) evaluation using pneumatic slug tests, a Geoprobe Systems® direct push system (model DT6610DT), and the Screen Point 16 (SP-16) showed that the lake beds are underlain primarily by fine sands of eolian origin (*K* ranges from 0.3 m/day to 15 m/day with mean K=4.8±4.6 m/day). Rare exceptions are more characteristic of coarser sands (possibly of fluvial origin). These data correspond well to previously obtained results from air injection tests by Goss and Zlotnik (2000) and constant-head infiltration tests by Sweeney and Loope (2001).

Preliminary Conclusions.

Mapping lake water chemistry data, finalizing water chemistry and stable isotope analyses of ground water and lakes, and core analyses are in progress.

Groundwater is significantly less saline than the lake water. This strongly suggests the evaporative nature of lake salinity, because sources of saline groundwater have not been detected directly in neither of eleven cases.

Differences in lake salinity cannot be explained by hydraulic or aqueous properties of the surficial aquifer. Existing groundwater-lake water gradients suggest that mass exchange can be strongly controlled by the force balance of density-driven and regional topography-driven flow.

Information Dissemination:

A manuscript " A case study of direct push methods for aquifer characterizating in dune-lake environments" (V.A. Zlotnik, M. Burbach, J. Swinehart, D. Bennett, S. Fritz, D. Loope has been prepared for submission to Ground Water or Groundwater Monitoring Review and Remediation

Contributing materials and a short narrative for Nebraska Educational Television Network program "Statewide" on Sandhills lake research (shown in December 2004, February 2005)

General information was disseminated among representatives of the rancher community in the Garden County (J. Cooper, G. deWitt, M. Eldred, and J. Parker)

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